

# Valmet

## Technical Paper Series

## Working Towards a Safer Recovery Boiler Operation

### Introduction

The recovery boiler is an integral part of the pulp mill. It is used for two purposes; to recover the pulping chemicals from the black liquor and to produce thermal energy in the form of high pressure steam. This steam is used both for process and electrical power production. Chemicals are recovered in the form of smelt from the bottom of the furnace. Smelt is comprised of molten sodium salts, mostly in the form of sodium sulfide ( $\text{Na}_2\text{S}$ ) and sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) with a smaller amount of sodium sulfate ( $\text{Na}_2\text{SO}_4$ ). It is critical in a recovery boiler to prevent contact between water and molten smelt as this can lead to a violent physical reaction better described as an explosion. In addition to the risk of explosion, combustion in the recovery boiler creates very hot gases and highly corrosive molten ash in the lower furnace. The black liquor that fuels the recovery boiler is also hot and highly caustic. Traditionally, operators have performed a number of physical tasks around the recovery boiler that potentially may have them come into contact with smelt, black liquor, hot gases and ash during furnace pressure excursion (positive furnace pressure) and process upsets (smelt rushes, heavy dissolving tank activity). These tasks include rodding and cleaning the smelt spouts and air ports as well as inserting, removing and cleaning liquor guns.

Valmet has developed and perfected several auxiliary devices that serve to both automate as well as either remove the need for direct operator involvement or to minimize exposure to unsafe working conditions. This paper will provide an overview of the development of these products and their applications for improving operator safety, as well as actual return on investment they bring by making the operation of the boiler more stable.

## Smelt Spout micro-hood arrangement

The spout deck on a recovery boiler is considered the most dangerous area for operators and one of the leading causes of recordable injuries. Operators are typically required to wear cumbersome PPE that can resist splattering of molten smelt while working on the deck which can make it more completing their maintenance tasks more difficult. Older recovery boilers were typically provided with large hood systems that sometimes covers more than one spout (**Figure 1**).



Figure 1. Old style large hood covering three spouts



Figure 2. Large opening below spouts and dried smelt covering internals and smelt spout

The logic behind the use of the large hoods was to keep surfaces as far as possible from the spouts to avoid smelt splatter and build-up on them. In most cases, this has proven to not be the case. In fact, operational results find it very common for smelt to spray onto the rear hood wall causing large deposits to form creating an excessive rate of wear to the hood enclosures. Many large hood systems were also notorious for having numerous internal components (shower headers, support bars, etc) which were shelves for smelt to collect on (**Figure 2**) leading to more significant operational issues. Major disadvantages of this arrangement are that it reduces accessibility to the spouts for cleaning, makes maintenance more difficult and allows for the potential of significant infiltration of air in the dissolving tank vent stack. It also usually requires removal of the large hoods and the addition of scaffolding in the dissolving tank in order to perform spout changes and standard annual maintenance.

To improve safety and make smelt spouts more accessible for cleaning, several recovery boiler suppliers developed smaller individual hoods for the smelt spouts, referred to as mini or micro-hoods. Compared to the larger hood designs, this arrangement allows for easier access to the individual spouts for cleaning and maintenance (**Figure 3**).

It also allows for the shatter jet to be placed closer to the spout resulting in a more downward angle of shattering. Along with these design improvements came a wave of several other modern safety related product upgrades including dual shatter jets, externally mounted shower bar headers and more reliable mounting interfaces for the smelt spouts. Organizations such as BLRBAC have published recommendations and best practices for spout system operation including the use of a dual shatter jet which allows for a backup shatter jet to increase reliability of shattering during heavy smelt flow events.

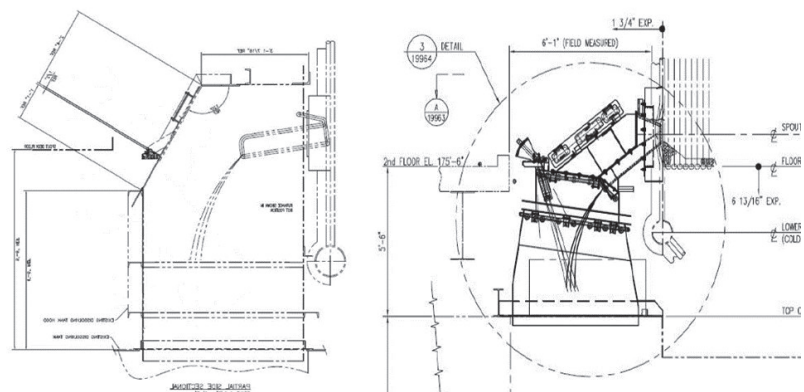


Figure 3. Large spout hood (left) compared to the “micro” hood system (right)

Upset operating conditions in a recovery boiler can result in smelt splashing, excessive smelt run-offs and high dissolving tank activity with the potential for explosions. For these reasons, the smelt spout deck is considered one of the most dangerous areas on a recovery boiler and requires a significant focus on safety in an effort to prevent injury to personnel. Introduction of these smaller individual hoods (**Figure 4**) also allowed for the development of an automated spout rodder to perform basic cleaning operations.



Figure 4. Large hood replaced by 3 individual spout hoods

## Spout Cleaning Robot

In 2008, a new system was developed utilizing an independent robotic arm that performs repetitive tasks similar to those in the manufacturing industry. Based on the space available and the spout deck layout, the robot can be mounted either on an overhead sliding rail (**Figure 5**) or on a rail system on the floor (**Figure 6**).



Figure 5. Overhead mounted robot



Figure 6. Floor mounted robot

The spout robot can be programmed to perform a number of specific tasks with the most common being the actual cleaning of the individual spouts, hoods and shatter jets. A typical cleaning sequence involves the robot moving to a specific spout position, checking its position against a known fixed point near the spout, opening the spout cover, and cleaning the spout, shatter jets, and inside of the hoods above the dissolving tank. After the cleaning cycle is completed, the robot returns to the “home” position on one side of the spout deck. To ensure the safety of operators, a fence barrier or light gate system is installed around the spout deck to power off the robot in the event that an operator enters the area within its range of motion. From the safety of the control room, a camera located on the robot arm allowing the operator to monitor performance of the robot and ensure the spouts and hood system are cleaned properly. In addition to the cleaning sequence, the robot has the potential to also be programmed for tasks such as plugging spouts, extracting smelt samples and adjusting shatter jet. The first robot was commissioned in 2008 to service 7 spouts on a large recovery boiler in Finland. Today there are eight (8) robots in service globally with plans for additional robots in various phases of customer development.



Figure 7. Typical stationary liquor gun assembly

## Liquor Station with Automated Port Rodder

A second area placing operators at risk resulting in numerous recordable lifting and burn injuries reported annually, is working around the liquor guns. Typical recovery boilers in North-America normally operate with 4 to 12 liquor gun openings. The number of active liquor guns will vary based on the load, product liquor solids and nozzle size in use. Since the late 80's, most recovery boilers have been converted from oscillating liquor guns, where the complete assembly was moving up and down or in an elliptical fashion in the port opening, to stationary firing where the assembly is placed in a fixed position in the opening (**Figure 7**).

The typical method to mount the liquor gun assembly involves the operator manually inserting the liquor gun inside the furnace opening and securing it in a clamp system. This operation requires the operator to be in close proximity to the opening exposed to furnace radiation and the opportunity for blowback of hot gases, hot liquor and molten ash while simultaneously requiring the operator to manage the weight of the liquor gun and hose in relatively awkward positions. Once in operation, the liquor guns and furnace openings tend to accumulate liquor and other deposits that require the operator to manually clean them. If the cleaning is not performed on a regular basis, the liquor spray pattern is negatively affected and the liquor nozzle can overheat, shortening service life (**Figure 8**).

Liquor stations were developed to make it both safer and easier for the operators to work around the liquor guns (**Figure 9**). The liquor station allows the operator to mount the gun assembly in the cradle and adjust it once while the unit is retracted and the safety door closed. Once the gun assembly is in position, the safety door can be raised and the cradle rolled into the furnace and locked in position with the operator standing to the side of the furnace opening as opposed to being almost in front of the opening with the more conventional arrangement. The cradle design secures the liquor gun in a way that ensures it is always at the optimal position and angle in the furnace for consistent liquor introduction into the furnace. The older clamp system does not offer this feature, often relying on the operator to make the required adjustments while also trying to secure the gun assembly despite being exposed to furnace operating conditions.

The automated rodder device included in the station is used to both clean the deposits off the liquor nozzle to ensure a more constant liquor spray pattern and assist with cleaning the port opening to allow for cooling air flow around the nozzle. This reduces the need for operator intervention to perform these cleaning tasks. As a result of implementing this system, multiple customer references report improved bed control, more stable furnace operation, improved emissions and longer service life of liquor nozzles. The ergonomic design of the station also reduces the potential muscle strain on the operator by minimizing the amount of required lifting and handling of the liquor gun and hose assembly while performing maintenance activities. Today there are more than 50 recovery boilers globally (25 in North America) operating with this type of system.

## Automated Port Rodders

Port rodders have been offered for recovery boilers since the 80's. Since that time, air systems have evolved from configurations having many small ports to the modern design featuring a smaller number of larger ports. For example, primary air ports previously on 9" to 12" spacing are now typically on 18" to 24" spacing. Secondary, tertiary and on some boilers quaternary air levels also feature a reduced number of ports, typically positioned on the front and rear walls. The most popular port rodder today utilizes a one-punch, cookie cutter type design where each air port is equipped with an individual unit driven by an air cylinder. Automated port rodders were developed based on the need to limit operators from potential exposure to hot air (300 to 400 °F), exposure to NCG's when



Figure 8. Liquor and ash accumulation on liquor nozzle (left), damaged nozzles from overheating (right)

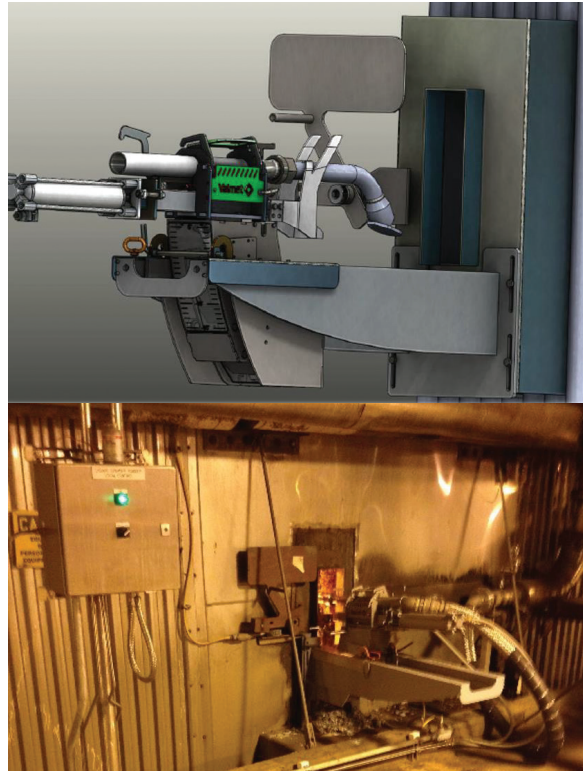


Figure 9. Liquor station schematic shown in retracted position and actual unit in inserted position

air ports are used to inject dilute non-condensable gases (DNCG's) into the recovery boiler for incineration of these odorous gases, and the potential for furnace blowback when manually rodding the air ports. Lastly, upgrade to the air system on existing recovery boilers may require the air ports to be located at elevations that make them difficult to access as the optimal location for the air level does not match the existing building floors and platforms.

Recent improvements in design of cutter heads and stronger cylinders capable of handling the duty-cycle of a hot environment, reduce the risk of the port rodders inability to retract after insertion into the air port. Additional features have been added to standard primary air port rodder arrangements (**Figure 10**), including sliding mount assemblies (**Figure 11**) that minimize direct exposure to the hot gases allowing operators to remove the unit from the boiler and complete servicing of the complete unit including cutter assembly replacements “on-the-run” (**Figure 12**) while the boiler remains in operation.

## Disposal in Recovery Boiler

These updated design features of greater significance when taking into account the smaller number of air ports and the industries drive to extend the duration between major maintenance outages for the recovery boiler. Automated port cleaning has also been demonstrated to provide more stable boiler operations and to help minimize emissions.

## Conclusion

Significant strides have been made to improve the safety of personnel during recovery boiler operation in recent years. Innovative products have been developed that offer more reliable automated features, based on modern recovery boiler arrangements, significantly reducing hazardous exposure of operators in areas such as the smelt spout and liquor firing decks and the combustion air system. In combination with upgrades to the spouts arrangement, a robot can be used to automate cleaning of the spouts along with several other tasks on the spout deck where operators are required to use extensive and cumbersome PPE to perform these tasks. Liquor stations can also reduce operator exposure to the dangerous environment of the furnace, reduce muscle strain associated with handling cumbersome equipment and improve boiler operation. Lastly, air port rodders have improved in both reliability and maintainability, and are available for all elevations of the combustion air system. Automation of air port cleaning helps both reduce exposure as well as potentially physical strain for the operators. In summary, the focus in development of these automated products help by providing the tools essential for mills to improve operating efficiencies and sustain more consistent performance through outage cycles while creating a safer workplace environment for personnel.

*This white paper combines technical information obtained from Valmet personnel and published Valmet articles and papers. Valmet provides competitive technologies and services to the pulp, energy and paper industries. Valmet's pulp, paper and power professionals specialize in processes, machinery, equipment, services, paper machine clothing and filter fabrics. Our offering and experience cover the entire process life cycle including new production lines, rebuilds and services. We are committed to moving our customers' performance forward.*

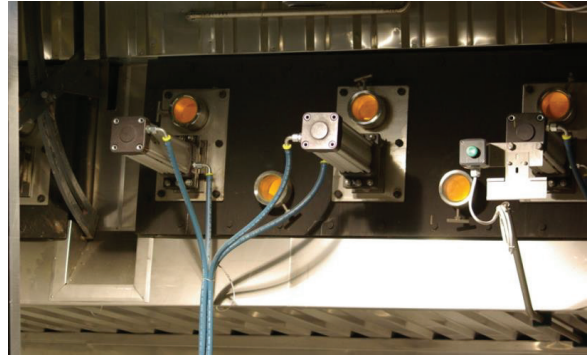


Figure 10. Standard port rodders

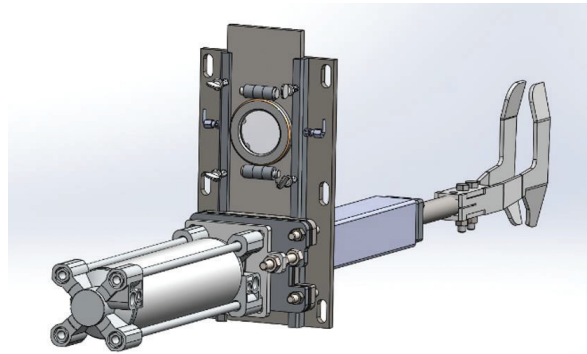


Figure 11. Typical primary air port rodders



Figure 12. “on-the-run” Serviceable port rodders